SUMMARY REPORT ON ENVIRONMENTAL MONITORING

RELATED TO

THE PEARSON COLLEGE-ENCANA-CLEAN CURRENT

TIDAL POWER DEMONSTRATION PROJECT

AT RACE ROCKS ECOLOGICAL RESERVE

FINAL REPORT

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FINAL REPORT

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1.0 INTRODUCTION

Race Rocks is a complex comprised of one island (Great Race Rocks) and a number of smaller islets and rocky reefs along the northeastern shore of Juan de Fuca Strait, separated from Vancouver Island by Race Passage and Bentinck Island (Figure 1). Race Rocks is the southern most point on Vancouver Island and is located approximately 22km southeast of Victoria, BC. The area was established as a BC Ecological Reserve in 1980 and proposed as a federal marine protected area (MPA) in 1998. The Reserve is bounded by the 20-fathom (36.6m) depth contour and encompasses 227 hectares, of which 225 hectares are seabed. Race Rocks Ecological Reserve (and subsequent MPA) was created to protect the diverse, high current influenced intertidal and subtidal invertebrate, marine algae and fish community and marine birds and pinnipeds (seals and sea lions) that use Race Rocks for breeding and non-breeding purposes.

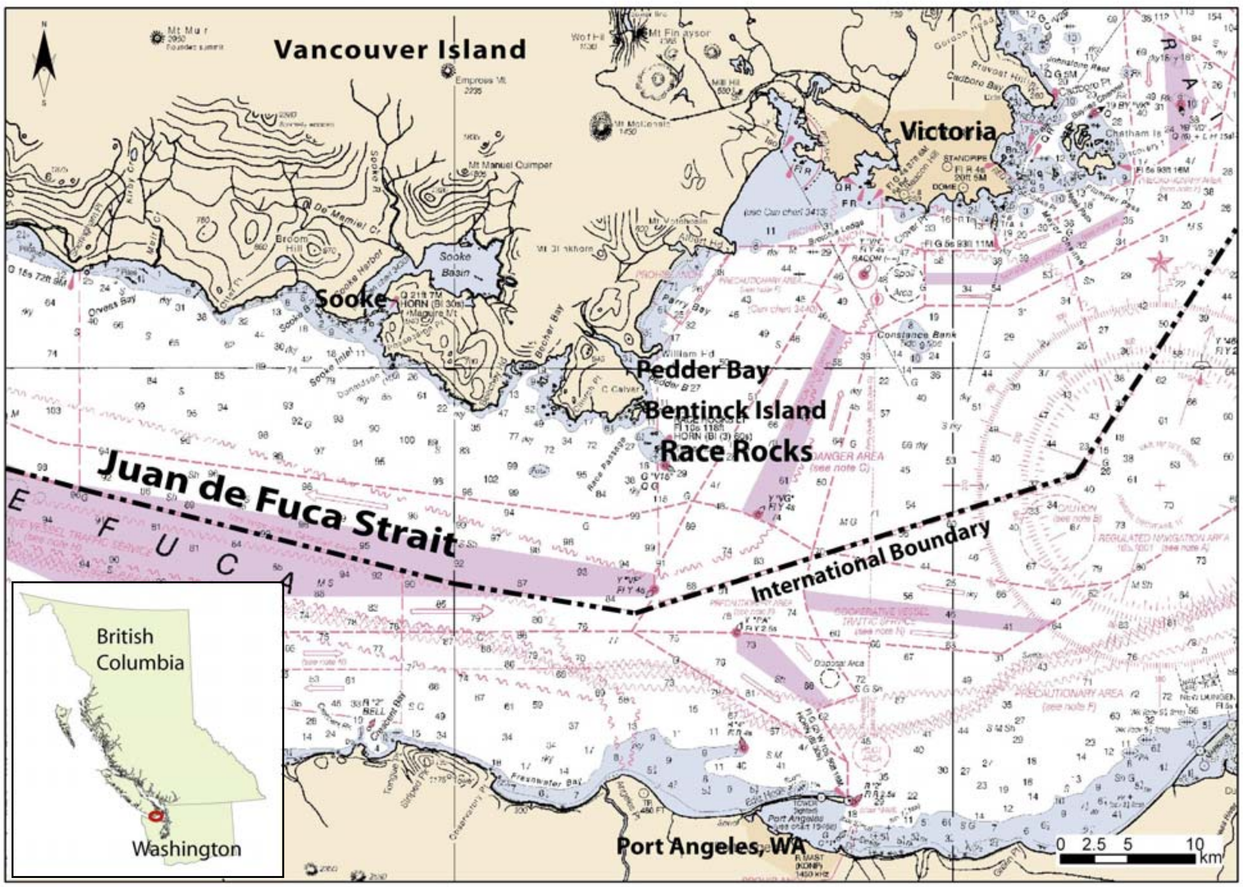


Figure 1. Location of Race Rocks Ecological Reserve at the southern tip of Vancouver Island (red circle, inset).

Lester B. Pearson College of the Pacific (Pearson College) operates several provincially owned buildings and associated equipment located on Great Race Rocks including a guardian residence, a guest house, a concrete boat dock (jetty) and launch, a boat house, a tank room, a generator room with two diesel generators, two diesel tanks, fuel pumping equipment and a fixed crane and crane shed (see Figure 2, Section 2.1). The Canadian Coast Guard leases a light tower and support infrastructure also located on Great Race Rocks.

In 1997, the Coast Guard installed solar panels and batteries to provide power to the energy demanding foghorn and light tower operations. Since 1997, Pearson College has been responsible for raising funds to operate the diesel generators that supply electricity to the rest of the island. Due to the increasing economic and environmental costs of operating the diesel generator and the recognized potential for developing a sustainable energy system that would create a self sufficient power supply to the island, Pearson College investigated the feasibility of designing and operating an alternate energy system for Great Race Rocks.

Following the results of a feasibility study from research conducted through the Institute of Integrated Energy Systems at the University of Victoria (IESVic), it was concluded that:

- sufficient renewable resources (tidal, wind and solar) were available to develop an integrated energy system that was capable of providing a reliable power supply to Race Rocks, and,
- tidal energy would have the least environmental impact due to the size of system required and would provide the most reliable power source with the least amount of required storage (Niet and McLean 2001).

In 2005, a partnership between Pearson College, EnCana Corporation and Clean Current Power Systems Incorporated to build, install, operate and monitor a 65kW free-stream tidal generator in Race Rocks Ecological Reserve was announced. Installation of the proposed tidal turbine generator (at a water depth of 20m) and the supporting submarine cable was planned for fall and winter 2005 followed by operation and maintenance testing commencing in 2006 and continuing for a five year period. Due to the Ecological Reserve and MPA status of Race Rocks, environmental monitoring was required at various stages of construction (prior to, during and post construction). This report summarizes the environmental monitoring tasks completed between April 2005 and October 2006.

1.1 Environmental Monitoring Objectives

Archipelago Marine Research Ltd. (Archipelago) was contracted by Pearson College to provide environmental monitoring services for the duration of the construction phase of the tidal turbine demonstration project. Monitoring objectives for the project were to:

1. **Pre Construction Phase**:
    - develop a baseline record of terrestrial and marine species and habitat (community composition and spatial coverage) in the area of anticipated construction impacts by completing a field survey at the proposed upland directional drill location, upland and marine cable route and tidal turbine location prior to construction.

2. Construction Phase:

- monitor the effects of land and marine construction on marine bird (particularly during nesting and rearing lifecycle phases of glaucous-winged gulls, Pigeon guillemots, pelagic and Brant's cormorants and black oystercatchers) and marine mammal (harbour seal pupping stage, California and Northern sea lion haul out) behaviour by recording observational data at key points of the construction process;
- document construction methodology and resulting impacts to the marine environment (e.g., construction equipment positioning, release of drilling effluent; and,
- provide ongoing feedback and evaluation to environmental control personnel at Pearson College and individual contractors during the construction phase.

3. Post Construction Phase:

- monitor the effects of the construction phase on the benthic environment at the tidal turbine site, along the submarine cable route and at other areas of potential impact identified during the construction phase by recording observations on biophysical features and collecting underwater video imagery.
- provide a report that summarizes the environmental monitoring observations and includes recommendations for monitoring the recovery of the seabed in the vicinity of the tidal turbine over a five-year period.

2.0 PRE CONSTRUCTION MONITORING

2.1 TERRESTRIAL BASELINE MONITORING

The collection of terrestrial baseline information prior to the start of upland construction activities consisted of recording observations at the directional drill equipment staging area and along the proposed upland cable route from the drill location to the battery storage room (renovated generator room) (Figure 2) during an on site orientation conducted by Garry Fletcher (Ecological Reserve Guardian Warden) on April 6, 2005. Information documented included:

- details on location and timing of seabird nesting, rearing and foraging activities and marine mammal foraging, pupping (harbour seals) and other behaviour;
- identification of the original barge landing site east of the Guardian house;
- identification of upland area where the directional drill machinery would be located;
- identification of the proposed upland cable route from the drill site to the generator room; and,
- details of the construction associated with the expansion of the generator room.

Following the completion of the orientation, several observations were made:

1. There was no anticipated impact to rare or endangered (SARA (Species at Risk) listed, BC CDC) terrestrial plant or marine algal and invertebrate species related to the barge landing and upland directional drill activity. The nearest location of the rare terrestrial plant, *Romanzoffia tracyi* (Photo A) to planned construction activity was in the rocks southeast of the Guardian house, outside the footprint of the construction area.

2. Impacts to upland vegetation (compaction, smothering, die off) from sea lion haul out (winter) in the proposed construction area were visible (Photo B). Spring growth of terrestrial plants in this area typically occurs once the sea lions vacate, therefore impacts from the proposed construction activity in April were considered very low.

3. In order to provide baseline biophysical information and to assess potential impacts to marine habitats associated with the construction activities, a need to document community composition and cover along intertidal transects at the proposed barge landing area and directional drill location was identified (described in Section 2.2.1).

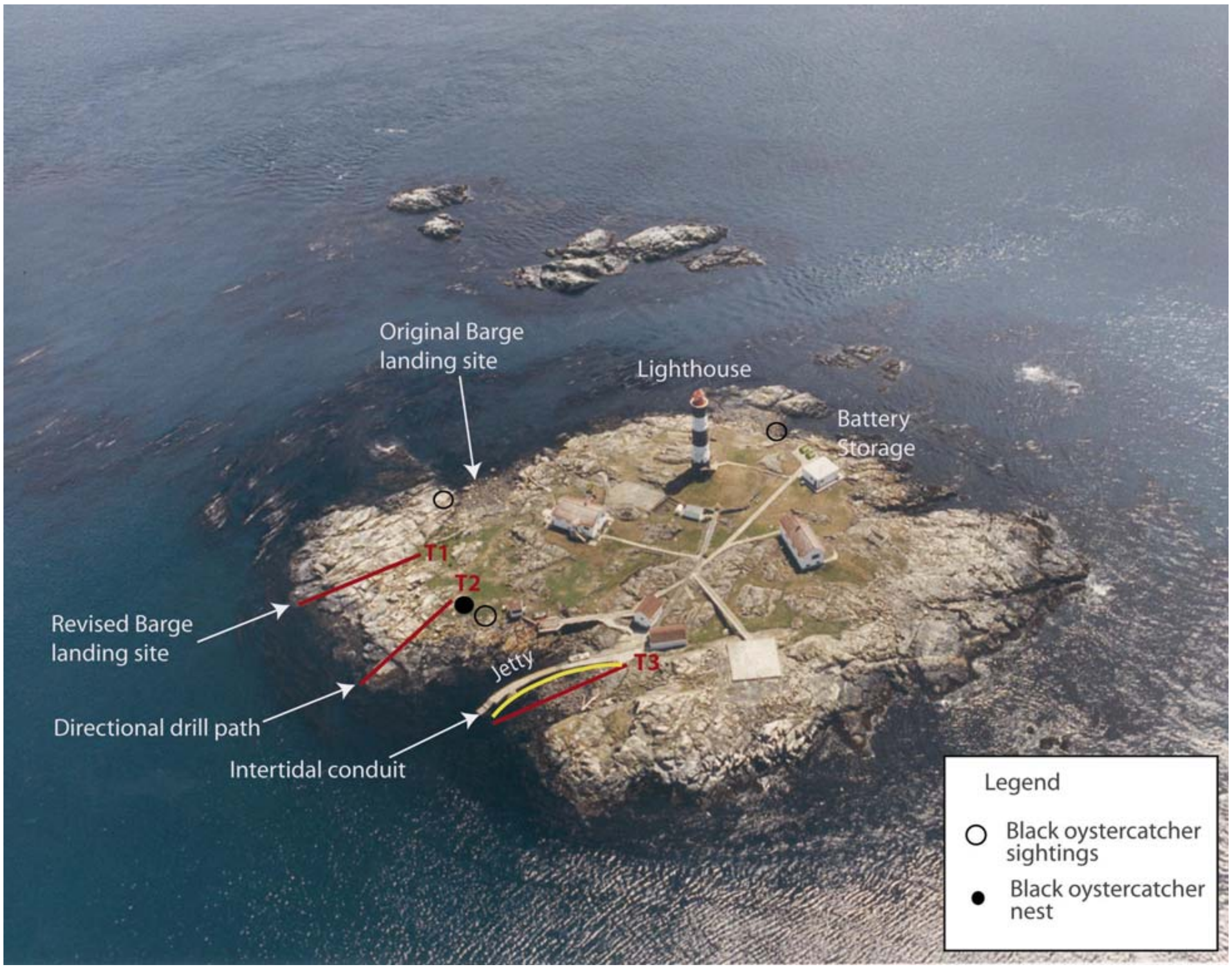


Figure 2. Location of intertidal transects (T1 – T3) and black oystercatcher sightings and nest.

4. Given directional drill activity was planned for April, observations on seabird (including Pigeon guillemots, glaucous-winged gulls, cormorants) behaviour were focused on black oystercatcher nesting activity. Three pairs of oystercatchers were identified during the site orientation (see Figure 2), each located near a site of potential disturbance (i.e., directional drill site, the barge landing site and the generator room). An oystercatcher nest (Photo C) was located 5m from the proposed directional drill site; however, there were no eggs present in the nest.

5. Potential disturbance to harbour seals hauled out in the vicinity of the directional drill and generator room was considered low; however, structured observations to document seal behaviour were planned during drill and generator room construction activities.

2.2 Marine Baseline Monitoring

2.2.1 Directional Drill Site and Barge Landing Area

Following discussions about the details of the proposed directional drill operation (siting, timing, and equipment), a field visit was conducted on April 27, 2005, to:

- document the black oystercatcher nest position;
- collect detailed biophysical information (elevation, distance, algal and invertebrate species composition) along two intertidal transects, one at the proposed revised barge landing site and one along the directional drill route; and,
- meet with the generator room construction crew (Roma Construction) to review environmental concerns associated with the generator room expansion.

Figure 2 shows the location of the intertidal transects (T1 and T2), and the oystercatcher nest.

Two students from Pearson College assisted in the collection of biophysical information along T1 and T2 during a 0.39m low tide cycle (Photo D). A summary of the detailed physical and biotic community assemblages and associated tidal elevation and distance along each transect is provided in Appendix Table 1.

Typical algal and invertebrate species found on the bedrock in the upper intertial zone include *Porphyra perforata*, fine filamentous green algae, limpets and barnacles. Species present in the mid intertidal zone include *Fucus* sp., *Endocladia muricata*, *Halosaccion* *glandiforme*, *Ulva* sp., barnacles (including clumps of *Pollicipes polymerus*, gooseneck barnacle) and limpets (Photo E). Algal growth was denser in the lower intertidal zone and included *Phyllospadix* sp., bladed kelps (*Hedophyllum sessile*, *Alaria* sp., *Laminaria* sp.), filamentous, foliose and coralline red algae (including *Odonthalia* sp., *Palmaria* sp. and *Lithothamnion*). California mussels (*Mytilus californianus*) and large *Semibalanus cariosus* barnacles were present along with sea cucumbers (*Cucumaria miniata*), chitons (*Katharina tunicata*) and limpets (*Tectura*). No rare or endangered plant or invertebrate species were noted. Canada geese, gulls and black oystercatchers, displaced during the collection of the transect information, moved back to their locations once work in the area was completed.

A dGPS location and elevation (relative to chart datum) of the oystercatcher nest was documented. A single egg was observed in the nest (centre, Photo F) at 12:19 where no egg had been observed in the morning (10:15). Given the proximity of the nest to the drill site, it was determined that some mitigation (i.e. blind, barrier) would be needed to lessen the impacts of the drill activity. However, following this field visit, a decision was made not to proceed with directional drill activity due to geophysical considerations and other concerns, therefore mitigation was not necessary.

2.2.2 Jetty Site

An assessment of the biophysical conditions along the west side of the jetty and in the bay immediately adjacent was completed during a 0.38m low tide on May 12, 2005. Figure 2 shows the location of Transect 3 (mid bay) and the proposed construction alignment along the west side of the jetty. Information on algal and invertebrate species present along the jetty and in the bay along T2 was documented. A summary of the detailed physical and biotic community assemblages and associated tidal elevation and distance along T3 and the jetty is in Appendix Table 1. Typical species found in the intertidal zone are similar to those found at T1 and T2, although due to slightly different exposure regimes and substrate (more unconsolidated material in the bay in addition to bedrock) particular indicator species such as gooseneck barnacles and surfgrass (*Phyllospadix* sp.) were not present or were present with less abundance and/or varying distribution. As was the case along T1 and T2, no rare or endangered algal or invertebrate species were observed.

2.2.3 Submarine Cable Route and Turbine Site

The documentation of species and community assemblages along the cable route and at the turbine site prior to the sub-marine construction phase was completed using a combination of towed underwater video (SIMS-Subtidal Imagery and Mapping System) and diving. Below is a description of the survey methodology and resulting biophysical observations.

2.2.3.1 Survey Methodology

The majority of the cable route was surveyed using SIMS (375m of a total 450m, 83%) with the exception of the area of dense bull kelp (*Nereocystis leutkeana*) east of middle rocks (Figure 3). Video imagery was collected using both methodologies, with SIMS imagery geo-referenced using an onboard dGPS at a fix rate of one data point per second.

The SIMS survey was conducted October 6, 2005 over a 2hr period around the afternoon slack tide. Water depths ranged from 2mCD at the jetty (Photo G) to 19.8mCD at the turbine site. Boat tow speed was approximately 1knot, however the current influenced the speed at both ends of the slack window. Depth of the towfish above the seabed ranged between 0.5m and 1.5m (with the exception of the occasional entanglement with bull kelp), with most imagery collected at 1.0m above the bottom. The depth of the towfish (relative to CD) and trackline location data (UTM northing and easting, Zone 10) was burned on the imagery. Two copies of the SIMS imagery (burned on DVD) were provided to Pearson College.

Following the collection and review of the SIMS imagery, three dives were conducted in the following locations:

1. **Turbine site**:(October 26, 2005) Four divers (two from Archipelago and one student and one instructor from Pearson College), using a float and small anchor block marking the location of the turbine (at 19.8mCD), collected information on the invertebrate, algal and fish community within an approximate 25x25m area at the turbine site (see Figure 3). Archipelago compiled a list of species and collected video imagery while the Pearson College divers collected video imagery and specimens. Sea lions were present throughout the dive, and occasionally nipped at the student diver's fins and video camera.

2. **Northeast end of middle rocks:** (October 26, 2005) Two divers from Archipelago collected species information and video imagery along the 75m portion of the cable route (12.5m to 9.5mCD, north to south) that was not filmed using the towed underwater system. At the same time, several divers from Pearson College examined an alternative route along the north edge of the bedrock. Sea lions were present during this dive as well and similar interactions with divers occurred.

3. **Concrete jetty:** (November 8, 2005) Species information was collected from the base of the concrete encasement alongside the western edge of the jetty to the end of the bull kelp (+0.2m to 6.8mCD depth). While the SIMS imagery provided very good spatial coverage of the canopy forming kelps (*N. leutkeana* and *Pterygophora californica*) and megafauna (including sea urchins, anemones, fish, demosponges, hydroids), the focus of this dive was to document understory species obscured by dense vegetation in the shallowest portion of the cable route. Particular attention was given to documenting the presence of Northern abalone (*Haliotis kamtschatkana*), as this species had been previously documented in this area and is SARA listed.

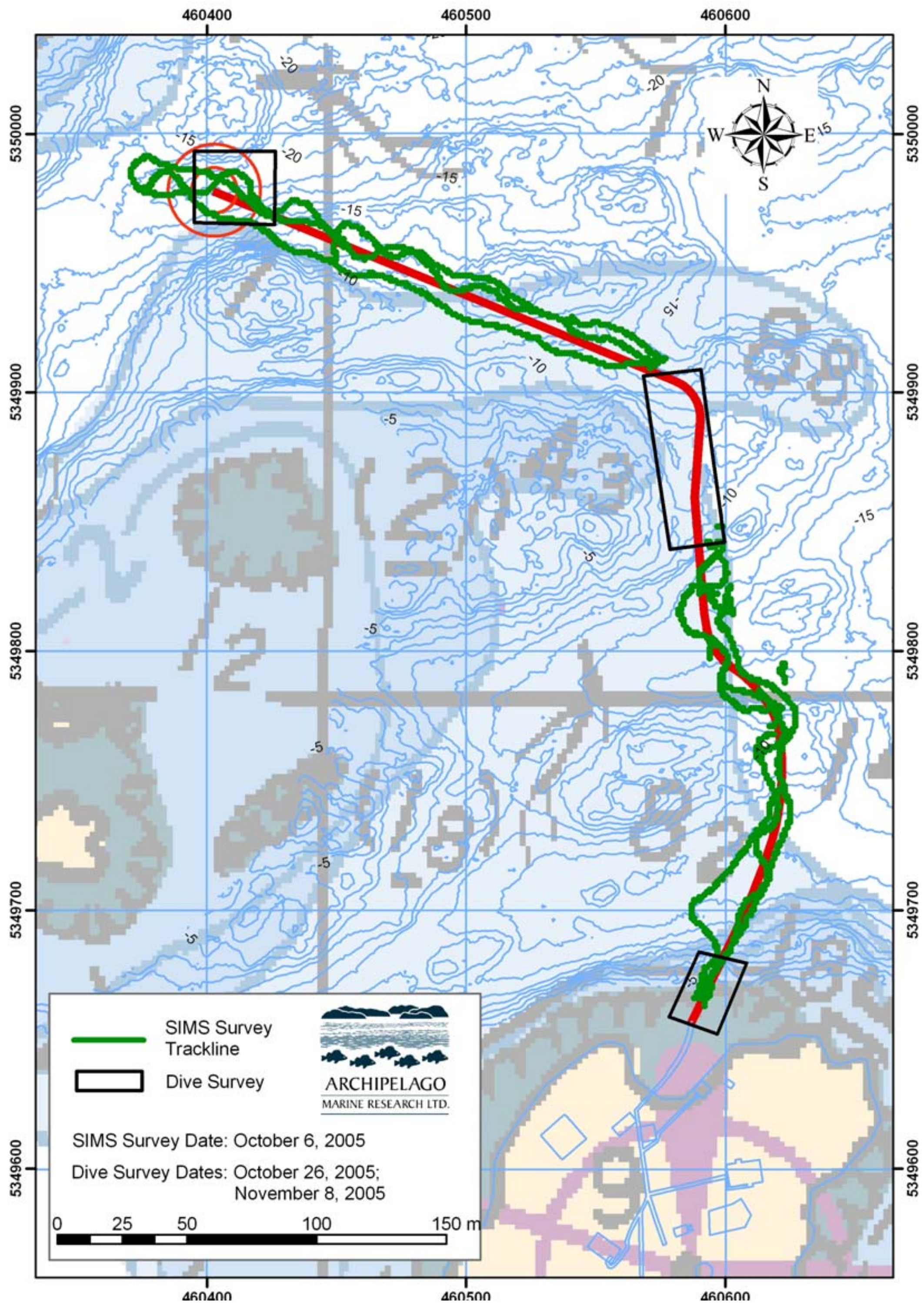


Figure 3. Towed underwater video and dive survey locations along the proposed cable route and at the turbine site.

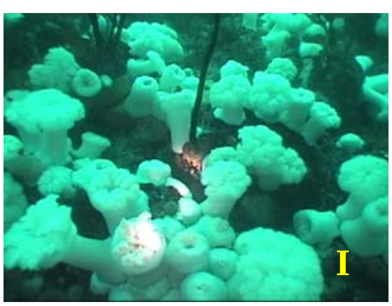
Video imagery collected during all three dives was provided to Pearson College in DVD format. All dive work required documenting the biotic community along the cable route and at the turbine site prior to construction was completed using the Pearson College vessel Second Nature as a dive platform. Efforts were made to combine the environmental monitoring tasks with other tidal turbine work conducted by Pearson College staff and students. Fieldwork was completed in an atmosphere of mutual learning, professionalism and attention to high safety standards.

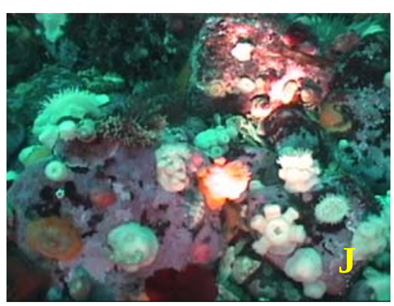
On October 17, prior to the dive work, a conference call between Clean Current (Russell Stothers, Turbine Project Manager), EnCana (David Lye, Team Leader Environmental Health and Safety Coordinator), Pearson College (Chris Blondeau and Garry Fletcher, Ecological Reserve Warden) and Archipelago Marine Research Ltd. (Pam Thuringer, Project Biologist) was held. The purpose was to review environmental aspects of the project to date and discuss any concerns related to the upcoming construction activity planned for November. There were no major environmental issues identified.

2.2.3.2 Survey Results

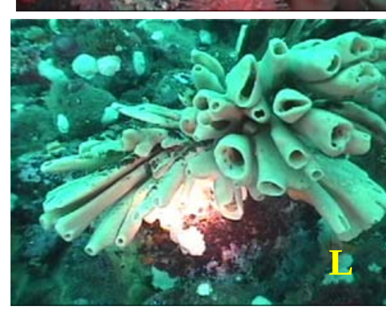
A list of flora and fauna observed during both the SIMS and dive survey is provided in Appendix Table 2. No soft corals, Northern abalone (listed as Threatened under SARA) or other rare or endangered marine invertebrates, fish or vegetation were noted. Although abalone have been documented in the vicinity of the jetty where suitable habitat exists (particularly to the immediate northeast), none were observed during the dive survey.

Dominant invertebrate species observed include sea urchins (primarily *Strongylocentrotus franciscanus*, Photo H), anemones (*Metridium giganteum*, Photo I, *Epiactis* and other anemones, Photo J), demosponges (various encrusting and erect species including *Isodictya* sp., Photo K), hydroids (including erect and encrusting hydrocoral), and ascidians (including the lobed compound ascidian *Cystodytes lobatus*, Photo K). There are large urchin barrens at depths greater than 8mCD between the jetty and middle rocks.





Fish species observed along the proposed cable route include kelp greenlings (*Hexagrammos decagrammos*)(both male and female), lingcod (*Ophiodon elongates*) and rockfish (Quillback, *Sebastes malinger* and copper, *Sebastes caurinus*) with kelp greenlings most abundantly noted.



Generally, the substrate along the cable route between middle rock and the turbine site is dominated by gravel (cobble and boulder predominantly, with limited shell hash and pebble) and bedrock/outcrops. More bedrock outcrops, with pockets of shell hash and fewer boulders on bedrock, characterize the cable route between middle rocks and the jetty. The predominantly hard bottom provides substrate for diverse marine vegetation, which includes the bladed kelps *Laminaria* spp., (*Laminaria saccharina/bondgardiana* in the shallow subtidal zone and *Laminaria setchelli* >12m depth, Photo M), *Costaria costata* (dominant between 10-12mCD range), *Cymathere triplicata*, and *Pleurophycus gardneri*. *Pterygophora* (Photo N) and *Nereocystis* are the dominant canopy kelps at depths less than 9m in the vicinity of the jetty. Foliose and filamentous red alga is present at all depth ranges.

It is important to note that vegetation typically dies back in the winter months, usually between late October and February. As a result, identification of some species can be problematic (e.g. stipes only), and density or seabed cover will be less than during the spring and summer months. Seasonal variability becomes important when comparing pre and post construction video. Urchin grazing can also greatly affect vegetation density (creation of urchin “barrens” on one extreme) and often it is difficult to determine whether a short woody stipe is the result of urchin grazing or winter die back (perennial/annual growing cycle, storms).

3.0 CONSTRUCTION MONITORING

3.1 Terrestrial Construction Monitoring

Environmental monitoring of construction in the upland area comprised of periodic observations of 1) the generator room renovations (starting April 2005) for battery storage, and 2) along the cable route (November 2005) between the jetty and the generator room. Below is a description of the monitoring activities.

3.1.1 Generator Room

An on-site meeting to review planned engine room construction activities and associated environmental concerns was held on April 27, 2005 with the foreman and construction crew from Roma Construction. The containment of sidewalk and building demolition material, the location of the portable cement mixer and containment of runoff, and the importance of minimizing the construction footprint and localized effects on nesting seabirds and harbour seals was discussed along with the proposed construction schedule.

Photos O-P show the generator room prior to construction and during sidewalk demolition. Demolition debris from the sidewalk was stockpiled on the concrete pad seaward to the demolition area (Photo Q). The concrete mixer was placed in the middle of the demolished sidewalk, where run off was contained in a localized area during cement mixing activity. Construction material was also stockpiled on the grass immediately adjacent to the generator room, with a barrier placed between the vegetation and material to minimize potential impacts. Finer material was covered to prevent dispersion into terrestrial seabird nesting areas or into the marine environment (Photo R).

Seabird and seal behaviour was observed prior to and during the operation of the jackhammer. Gulls, Canada geese, cormorants and black oystercatchers present on the bedrock south (southeast and southwest) of the generator room appeared undisturbed by the noise generated by the jackhammer. Harbour seal haul out behaviour on the bedrock immediately south of the generator room also appeared unchanged prior to and during jackhammer use. It is likely that jackhammer noise was not at a sufficient level above the generator noise to cause behavioural changes. The behaviour of the gulls present in the grass and rocks immediately north of the generator room also did not appear to change during jackhammer use.

Photo S shows the completed generator (battery storage) room with construction materials in the surrounding area removed. Impact to the surrounding vegetation was very low (temporary smothering) and full recovery was anticipated. Gulls with chicks remained present in the upland area adjacent the generator room as did oystercatchers and Pigeon guillemots on the bedrock within the intertidal zone seaward of the generator room.

3.1.2 Cable Conduit

Construction of the cable pathway between the boathouse and generator room commenced in early November, 2005. A discussion with the construction foreman (Roma Construction) on November 8, 2005, included a review of the work schedule (activity and timing). Photos and observations of the upland construction were taken following the completion of a dive in the shallow subtidal zone north of the jetty on the same day.

Although a large portion of the area along the sidewalk was fertile soil, it was anticipated that there would be a need to break up some concrete and bedrock immediately beside the sidewalk to accommodate the cables. Photo T shows the construction path immediately west of the sidewalk, while Photos U and V show close views of the bedrock and concrete demolition areas. Most of the concrete that was demolished alongside the sidewalk was placed back into the fill area while some was hauled away with other constructions spoils.

Observations on bird behaviour (gulls and cormorants) in the vicinity of the construction work were completed over a 45-minute period on November 8, 2005. Observations were made prior to, during (Photo W), and after jackhammer activity. There appeared to be little to no adverse effect on bird behaviour in that individuals and/or groups did not take flight immediately after work with the jackhammer started. Photo X shows both gulls and cormorants perched on the rock (immediately east of the construction area) during the onset of jackhammer use. A smaller, quieter and more mobile jackhammer than the one used for demolition work at the generator room, was employed.

3.2 Marine Construction Monitoring

3.2.1 Jetty and Cable Conduit

Construction along the jetty occurred between May 27 and June 21, 2005, commencing with drilling through the stairwell along the west side of the jetty (Photo Y). Construction material was brought on site with a barge and transported by hand to the construction staging area at the landward end of the jetty (Photo Z and AA). As the same construction company (Roma Construction) and foreman from the generator room work were used, the crew was aware of the environmental concerns in the

foreshore including 1) minimizing input of debris to the intertidal zone, 2) minimizing the construction footprint along the jetty, and 3) minimizing any runoff into the marine environment from concrete mixing activities. An on-site meeting was not deemed necessary. A Pearson College employee was on site every day to monitor construction activities. Remote monitoring via on-site cameras was used throughout the construction period to identify any environmental concerns. A visual scan of the bay was done every morning prior to construction to identify the presence of pupping harbour seals in the bay (none were observed).

An inspection of the intertidal zone after construction was completed on July 8, 2005. Photo BB shows the completed concrete encasement along the jetty. Although rapid colonization of algal vegetation on the concrete structure was anticipated in the lower intertidal zone, only a diatomaceous film had grown on the lower portion of the concrete trough to date. Impacts to the immediate area were contained within 2.5m of the jetty and consisted of a few patches of concrete rubble (Photo CC), which were subsequently removed upon request. In the immediate upper intertidal zone on the east side of the jetty where the concrete mixer was located, a small 1m X 0.20m area of concrete runoff was observed (Photo DD); however, there was no impact to sensitive or critical habitat.


BB


CC


DD

In summary:

1.The decision to build an encasement for the conduit along the west side of the existing jetty resulted in i) a reduction of direct impacts to nesting seabirds compared to the proposed drill site, ii) the incorporation of the conduit into already existing infrastructure, and iii) the completion of repairs to an aging dock.
2. Seabirds such as Pigeon guillemots, which had been temporarily displaced during construction, appeared to have moved back into the area (Photo EE).
3. Impacts to the marine invertebrate and algal communities will likely be temporary as complete re-colonization is anticipated.


EE

3.2.2 Pile Construction Preparatory Work

Prior to the onset of pile construction at the turbine site initially scheduled to start mid November 2005, direct contact with the drilling company (Robin Pederson – Construction Drilling Inc.) was made to discuss details of planned construction methodology. It was confirmed that oil/chemical spill response kits (with extra booms and padding) would be provided by the barge company (Fraser River Pile and Dredge). A description of the vegetable based drill oil (Matex R.D.O. 302 E.S.) and MSDS information was provided along with the MSDS information for the Terresolve hydraulic oil (EnviroLogic 146).

Components of proposed construction activity included:

- positioning the drill platform (barge) at the turbine site through the use of six anchor blocks (from surface);
- cleaning the overburden (boulder/cobble) in an approximate 2m x 2m area to locate the underlying bedrock (by diver);
- bolting a metal template to the bedrock (by diver) to guide the drill casing;
- lowering the casing to interface with the bedrock (mostly from surface); and,
- drilling (from surface).

It was anticipated that an approximate volume of $5m^3$ of drill cuttings would be air lifted to the surface into a cyclone, which is used to separate the water from the cuttings. The drill cuttings would then be taken off site for disposal while the drill effluent (water and fines, see below) would be discharged on site. Although considered a closed system, it was anticipated that

- approximately $0.5m^3$ of fine material (powder and fines < 1mm diameter) may still be present in the drilling effluent (discharged either from the surface or 6m depth, to be determined).
- the seal between the casing and bedrock would not be perfect, and as a result, approximately $0.5m^3$ of drill cuttings (estimated to be in the size range of ¾" – to 1" in diameter) may be deposited around the base of the drill casing.

Environmental concerns associated with drill cutting escape and fines in the discharge plume are 1) direct smothering of benthic marine organisms in a localized area, and 2) dispersion of fine sediments causing direct smothering of marine organisms and/or increased turbidity in the water column. Given the volume of predicted fines in the drill effluent and the strong currents and mixing that occurs at Race Rocks, suspension of fine material in the water column would be short term (one tidal cycle) and would not result in any significant accumulation of material on the seabed. Appendix 3 provides an estimate on dispersion rates based on reasonable assumptions of the operation and physical conditions of the site.

Although there will be direct impacts to benthic organisms in the immediate area of the drill site, all efforts are being made to minimize these impacts. The purpose of monitoring the seabed prior to construction is to be able to assess impacts post construction. It was anticipated that impacts would be localized (between 2-3m around the turbine site) and that re-colonization of benthic organisms would occur and would be monitored by Pearson College over at least a 5-year period.

Pile Installation - November 2005

On November 29, 2005, a barge and drill rig was on site to start with the pile construction (Photo FF). Planned monitoring activity included observations on i) marine mammal and bird behaviour, ii) construction equipment positioning and, iii) dispersion of the drill effluent plume. LGL's report on marine mammal and bird behaviour and disturbances at Race Rocks (Demarchi and Bentley 2004) was reviewed and the marine mammal observer was prepped and ready to deploy.

Due to weather and associated safety concerns, a decision was made to postpone construction activity until January 2006.

Template Installation – January 2006

Between January 10 – 13, 2006, divers from Can-Pac, supported by Pearson College and a local tug (Blue Water Contracting, Photo GG) attempted to install the drill template. Due to a thick layer of overburden material (>1m), the template was not successfully installed and the work crew left the site. Work was scheduled to resume once an appropriate weather window and construction schedule was established.

3.2.3 Pile Installation

Although other activity pertaining to this project occurred between January and July (e.g. transfer of batteries and electrical control equipment to the generator room, March 10-15, 2006), monitoring tasks described below are focused on the marine construction activity (pile installation and submarine cable laying – Section 3.2.4). The monitoring tasks for pile installation and submarine cable laying included 1) six days of field observations from Great Race Rocks and aboard the construction barges, and 2) 13 days (portions thereof) of remote monitoring via the Race Rocks web linked cameras (http://www.racerocks.com/racerock/video5remote.htm).

Prior to the commencement of the marine construction, a statement of work regarding both the pile installation (barge positioning, drilling, grouting and permanent anchor placement) and cable laying activities was provided for review and an opportunity to ask questions or offer feedback was presented. Rick Gillis from Fraser River Pile and Dredge (FRPD) addressed questions regarding the dimensions of the clamshell used to remove the overburden and the anticipated area of impact near the turbine site. Russell Stothers and Chris Blondeau addressed technical questions pertaining to construction activity and machinery/instrumentation. Once construction activity started, Russell, Gary Bowman (AMEC) and crewmembers from FRPD, Construction Drilling Inc. and Island Tug provided ongoing *in situ* explanations to questions that arose.

The planned timeline for pile installation was July 15 – 21, 2006, however due to a number of problems encountered, pile installation occurred over 22 days from July 15 – August 6, 2006. The main components of the pile installation included barge/equipment positioning, drilling, placement of the pile, grouting, and permanent anchor placement. Environmental monitoring during this construction phase occurred in the field (July 16, 21, 25) and via remote video (July 17, 24, 26-28, 31 and August 1, 3,4).

A barge from Fraser River Pile and Dredge anchored by six, 6 x 7 foot concrete blocks (Photo HH) (four 12.5 tonne and two 16 tonne) temporarily placed on the seafloor (anchor array shown in Figure 4), provided the drilling platform for pile installation. Monitoring observations were made both from the barge and Great Race Rocks and are described below.

3.2.3.1 Marine Mammal and Bird Observations

Methodology

Structured marine bird and mammal observations were collected over two days prior to and during rig anchoring (July 16), and before and at start-up of drilling activity (July 21). Animal and marine bird census surveys were conducted from the top of the lighthouse on Great Race Rock Island while continuous observations were collected in the region of the jetty. Figure 5 shows the geographic location of Race Rocks Ecological Reserve with islets and regions around the lighthouse numbered for observational reference (adapted from Demarchi and Bentley, 2004).

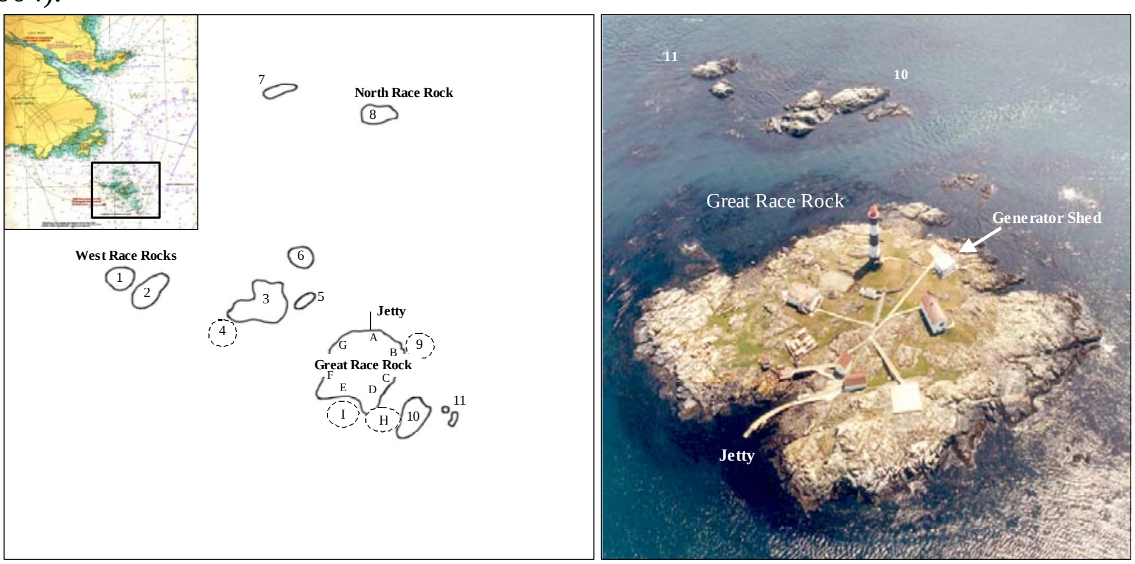


Figure 5. Geographic location of Race Rocks Ecological Reserve at the eastern entrance to Juan de Fuca Strait showing numbered regions in the Reserve for observational reference (left). Dashed lines represent rocky areas submerged at high tide. Turbine site is between Islets 6 and 8, with cables running along the seafloor from the turbine to the jetty, across Great Race Rock to the generator room (right). The majority of marine mammal and bird observations were collected from the top of the lighthouse and from the jetty. (Inset and aerial photograph courtesy of Pearson College website).

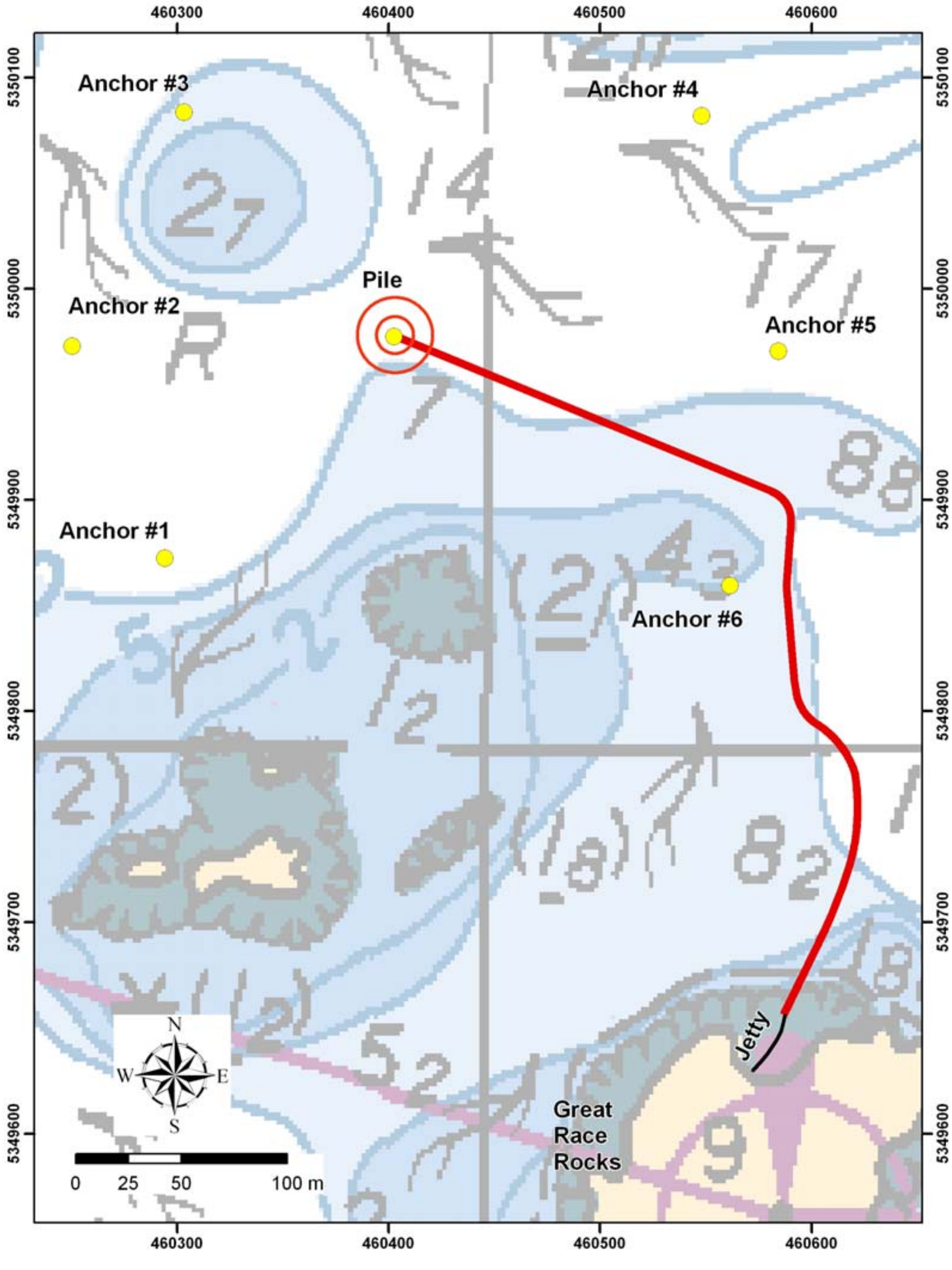


Figure 4. Location of six anchor blocks relative to the pile location and submarine cable (red line).

Censuses were conducted before and during drilling activity from the top of the lighthouse on the first day of observation at approximately 08:00, 12:00, and 16:00 hours, and twice on the second day at 08:00 and 12:00 hours. The lighthouse provided a 360º unobstructed viewing platform for observing animal behaviour, and only animals and birds resting on land were included in the censuses. Data recorded included date and time, tide state, islet number, species and number of individuals, as well as wind speed and direction, sea state, and visibility (Appendix 4 Tables 1 to 7).

Photographs were taken from the top of the lighthouse with a Nikon Coolpix 5700 digital camera for every region in the Reserve, and included general animal and bird photo documentation throughout each day. Photographs were also taken from the vicinity of the jetty. Binoculars were used to scan the surrounding waters for marine mammals every 15 to 30 minutes in addition to conducting continuous visual scans without binoculars. Three hundred and sixty degree long distance scans for whales were conducted with binoculars from the top of the lighthouse during each census survey. No whales were seen during the four days of observations.

Results

During rig anchoring and drilling activity in July, sea lions were the least abundant marine mammal sighted throughout the two-day observational period (Table 1). Three Steller (=Northern) sea lions (*Eumetopias jubatus*) were sighted on the first morning only and were all male, but disappeared approximately two hours prior to two tugs and the drilling rig entering the Reserve. The majority (>89%) of marine mammals in the Reserve were harbour seals (*Phoca vitulina)*. The minimum and maximum number of harbour seals visible at any one time was 61 and 340 animals, with the majority of seals hauled out on the east side of Great Race Rock away from rig activity (Figure 6). Northern elephant seals (*Mirounga angustirostris*) were the second most abundant marine mammal in the Reserve, comprising four adult males and one adult female. Immediately outside the Reserve, three harbour porpoise (*Phocoena phocoena*) were seen in the morning and in the afternoon on the second day of observation, at approximately one half mile and one mile, respectively, south west of Great Race Rock. The porpoise rolled a few times at the surface before disappearing.

Table 1. Summary of marine mammal and bird species observed on land in Race Rocks Ecological Reserve during censuses conducted from the top of the lighthouse in July before and during the drilling phase of the tidal current project.

Date	Time	Tide	Harbour Seal	Steller Sea Lion	California Sea Lion	Elephant Seal	Gull	Bald Eagle	Pigeon Guillemot	Pelagic Cormorant	Double Crested Cormorant	Oyster Catcher
16-Jul	8:00	High	61	3	0	5	451	2	53	0	0	0
16-Jul	12:00	Low	201	0	0	1	480	0	0	0	0	1
16-Jul	16:00	High	182	0	0	4	474	0	0	2	0	0
21-Jul	8:00	Low	340	0	0	2	227	0	57	0	5	5
21-Jul	12:00	Mid-tide rising	93	0	0	2	225	0	29	2	7	2

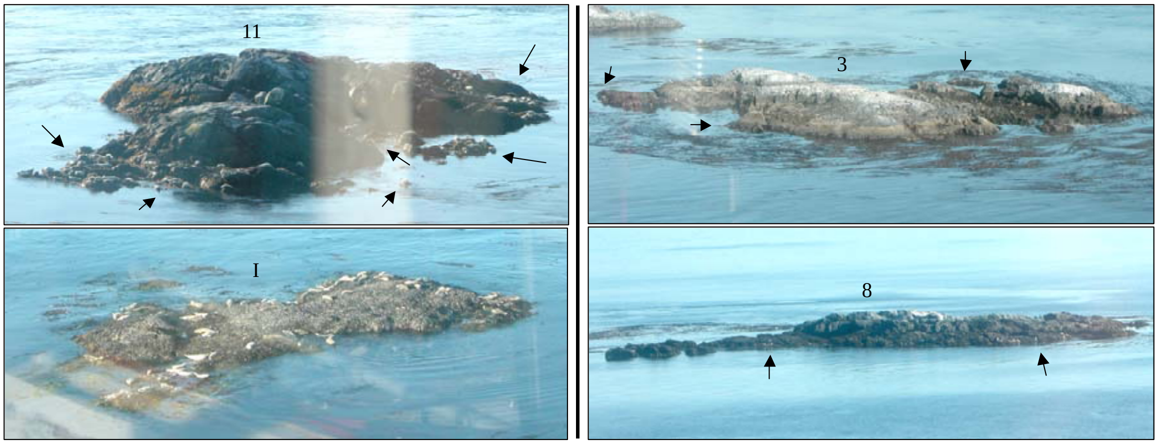


Figure 6. Photographs taken from the top of the lighthouse showing abundance of harbour seals (arrows) hauled out in the Reserve prior to drilling activity on July 21, 08:00 hours. Islets on the east side of Great Race Rock had the greatest abundance of seals (left, top and bottom photos), while regions west and north of Great Race Rock had significantly fewer seals (right, top and bottom photo). Numbers above each islet refer to their locations (see Figure 5).

Gulls were the most abundant bird species observed in Race Rocks Ecological Reserve during anchoring and drilling activity. The approximate minimum and maximum number of gulls was 225 and 480, with the majority of gulls using Great Race Rock and the islets west of Great Race Rock. The second most abundant bird species were pigeon guillemots (*Cepphus columba*), which were observed resting on Great Race Rock only. Often guillemots were seen floating on the water in various locations throughout the observation period, but only those resting on land were counted. Seven double crested cormorants (*Phalacrocorax auritus*) were seen resting on west Great Race Rock (area G) on July 21, and in the same region, a smaller number of pelagic cormorants (*Phalacrocorax pelagicus*) and black oyster catchers (*Haematopus bachmani*) were observed. Two juvenile bald eagles were sighted on West Race Rocks (Islet 2) on the first morning of observation, but disappeared approximately one hour prior to the drilling rig entering the Reserve. Three shore birds were also observed on Great Race Rock in the region of the jetty on July 21 but flew away before identification was possible.

Observational data of the effects of drilling on marine birds and mammals were collected prior to and at the start of potential construction disturbances. A disturbance was defined as increasing animal activity or displacing animals to the air or water. The northern elephant seals were consistently unresponsive to human activity, including human foot traffic on the same island. Few hauled out seals lifted their heads during barge activity, but the majority of seals were unresponsive. Pigeon guillemots were the primary species using the jetty and took flight at the approach of people and boats. These birds were quick to resettle after a disturbance, and overall bird activity increased only in reaction to human foot traffic on Great Race Rock. Animal abundance changed with the ebb and flow of tides, with more animals hauled out at low tide. At no time did drilling activity displace birds or marine mammals.

3.2.2.2 Other Observations

Observations from aboard the barge and through remote access (video) consisted of documenting construction activities through direct observation and interaction with project personnel and construction crews. Construction activities monitored included the removal of overburden on bedrock (see Section 3.2.2) by use of a clamshell dredge, positioning of the barge and drill equipment, drilling and drill effluent discharge. Below is a description of observations related to those construction activities. Observations regarding marine mammal and bird behaviour described in this section were made independently of the observations detailed in Section 3.2.3.1 and are non-structured in nature.

The clamshell dredge used to remove overburden (primarily boulder and cobble) from the pile site was a 3 cubic yard bucket (Photo II, marking in feet) weighing about 7000 kilograms and covering an area of approximately 1 x 3m when opened. The clamshell was used three times during the pile installation. The initial area of impact from the dredge spoils was anticipated to be approximately 10 – 15m^2.

Due to several problems encountered during this phase of construction (e.g., thicker overburden, equipment breakdown and replacement), it was necessary to remove a larger volume of overburden than anticipated; therefore, the area of impact to the seabed was also anticipated to increase. On July 17, Pearson College personnel collected video footage of the pile excavation site. At that time, it was estimated that the area of loose debris (overburden spoils) on the seabed (not including the excavation area of approximately 8m x 5m) was approximately 12m^2 and was concentrated in an area immediately south of the pile installation site. Post construction dive observations of the overburden spoils are detailed in Section 4.1.

Following the positioning of the barge on July 16 (see monitoring observations in Section 3.2.3.1) the drill (in the caisson) was positioned on the bow (Photo JJ) and the cyclone (Photo KK), used to separate overburden material from drill effluent (water and fines), and filter cloth were set up on the deck of the barge (Photo KK, LL). Drilling activity started on July 21 and continued on July 24-25 following replacement of one of the compressors. Due to the collapse of the caisson and damage to the drill, the remaining drill activity took place August 2-4, 2006, after a replacement drill was located and installed.

Observations of the drill effluent discharge to the marine receiving water included the following:

- Most of the drill effluent spilled off the starboard side of the barge (Photo MM) after passing through the filter cloth.
- A sediment plume was evident off the stern of the barge during a flood tide (Photo NN); however, the sediment plume dissipated very quickly.

- A larger sediment plume was visible off the bow of the barge during a slack tide (Photo OO); however the sediment plume dissipated rapidly (within 35 minutes) (Photo PP) following a tide change.
- Filter cloth was functioning as intended in that only fines were observed in the drill effluent discharge.
- Harbour seals hauled out on the nearby islets did not appear to be impacted from the drilling activity in that seal behaviour did not change (e.g., moving from an islet to the water, head lifting) at any time during the observations of the drilling and effluent discharge activities.

3.2.4 Submarine Cable Laying

From August 14 – 18, 2006, four submarine cables were laid on the seabed from a smaller self-propelled barge provided by Island Tug (Photo QQ). Observations were made from aboard the barge (August 16, 17), from Great Race Rocks (August 14) and remotely (August 16, 31). Below is a summary of the observations.

3.2.4.1 Marine Mammal and Bird Observations

Methodology

Submarine cable was laid approximately three weeks following the drilling activity. Using similar data collection methods as those used in the drilling phase, a single census of marine mammal and birds was completed from the lighthouse prior to the start of cable laying on August 15 (see Table 2), and informally from on board the self-propelled barge on August 17.

Results

The abundance of sea lions in the Reserve had increased significantly over the three-week period with 45 animals hauled out on land (Figure 7). However, the most abundant marine mammal was the harbour seal at 148 animals (Table 2). Birds continued to be the most numerous group overall at approximately 480 gulls, followed by 23 pigeon guillemots and four pelagic cormorants (Table 2).

Table 2. Summary of marine mammal and bird species observed on land in Race Rocks Ecological Reserve during a census conducted from the top of the lighthouse in the morning before the start of cable laying for the tidal current project.

Date	Time	Tide	Harbour Seal	Steller Sea Lion	California Sea Lion	Elephant Seal	Gull	Bald Eagle	Pigeon Guillemot	Pelagic Cormorant	Double Crested Cormorant	Oyster Catcher
15-Aug	9:00	High	148	16	29	4	480	0	23	4	0	0

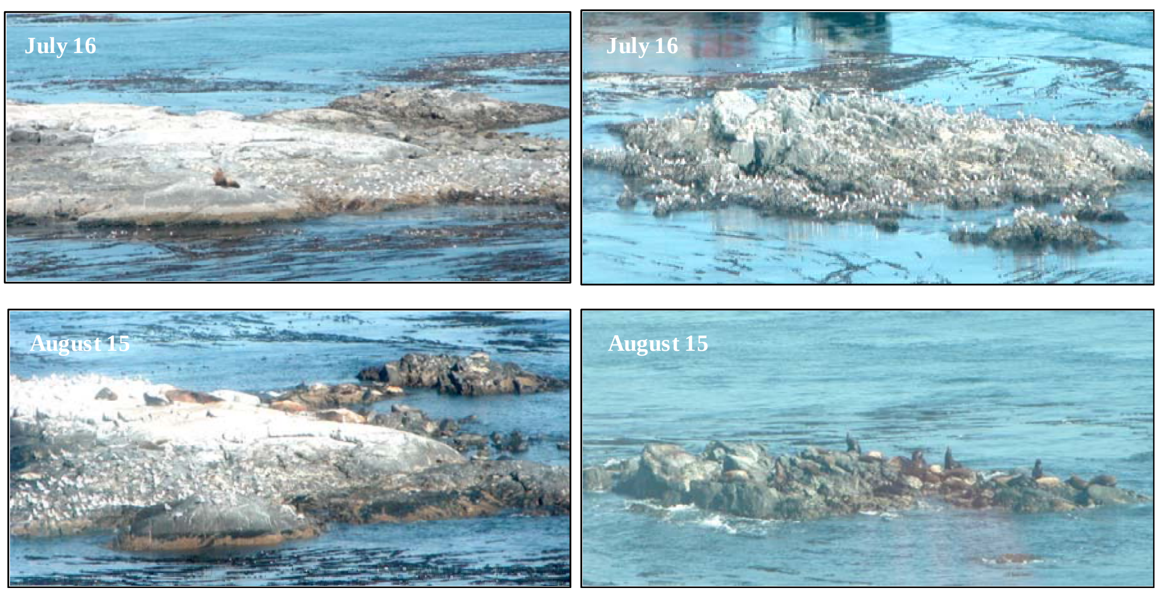


Figure 7. Photographs documenting changes in marine mammal abundance in Race Rocks Reserve over a three-week period. The top photographs show a single Steller sea lion hauled out on Islet 3 before disappearing two hours prior to the drilling rig entering the Reserve on the morning of July 16 (left), and gulls on Islet 6 on the same morning (right). Bottom photographs of the same islets three weeks later on the morning of August 15 show elephant seals and Steller sea lions hauled out (left), and California and Steller sea lions (right).

Sea lions on land and in the water in the vicinity of the turbine construction site were generally tolerant of the cable laying barge and attending work vessels (Figure 8, top). Three California sea lions were intentionally and repeatedly cleared off the jetty during the cable-laying phase, which only temporarily displaced the sea lions despite the presence of work crew. Harbour seals were present at all times throughout the Reserve and were mostly tolerant of human activity. Although a mother and pup harbour seal pair vacated their haul out when the cable laying crew approached the jetty, a second pair remained on land (Figure 8, bottom). Overall, foot traffic on Great Race Rock was the only observed disturbance (temporary) for birds and marine mammals in the Reserve.

Figure 8. Photographs taken from on board the self-propelled barge, documenting animal behaviour before and during cable laying activity in the Reserve, August 17, 20:00 hours. Upon entering the Reserve, California and Steller sea lions were hauled out on Islet 6 (top left photo), and showed no change in behaviour with the presence of the barge and divers in the water (top right photo). A mother and pup harbour seal pair (bottom left photo, left circle) and a California sea lion (bottom left photo, right circle) were hauled out on Great Race Rock east of the jetty during approach of the cable laying barge. The sea lion entered the water but remained in the vicinity while the seal pair did not move during transfer of cable along the jetty (bottom right photo).

3.2.4.2 Other Observations

On August 16, 2006, the second of four cables were laid along the submarine cable route. Monitoring observations were documented from aboard the barge and included an initial orientation of the vessel to identify safety items such as spill kits and first aid supplies.

After the second cable was laid, a rail was installed by divers at the seaward end of the concrete shute (conduit) at the foot of the jetty (Photo RR). Although several sea lions and harbour seals were present in the nearshore water surrounding the jetty, both the presence of the cable laying vessel and the associated activities of pulling the cable through the shute into the upland, tying off the barge to Great Race Rocks, and installing the rail in the shallow subtidal did not appear to impact the marine mammals in the vicinity. Photo SS shows a harbour seal pup and mother (black circle) hauled out on the rock <50m from construction activity for the duration of the rail installation. These mammals were also observed in the same location August 17, 2006 (see previous section).

During the duration of the monitoring on August 16, several other vessels were observed in the vicinity of Race Rocks and the construction area. Between one and 11 vessels, such as pleasure crafts and whale watching boats, were observed at any one time throughout the day.

3.2.5 Pile Extension Installation

On August 31, during the installation of the pile extension, marine mammal and bird observations were collected remotely via the Race Rocks remote video camera. At 17:00 hours a remote survey of the area provided a general census of animal activity prior to construction, and remote snapshots were taken for photo documentation. At 17:15 hours the rig and tugs were on scene between Islets 6 and 8 and divers were in the water. Islet 7 was mostly submerged in a high tide, and California and Steller sea lions occupied Islets 3 and 6 near the turbine site (Figure 9) as well as the jetty region.

Figure 9. Remote image showing orientation of barge activity in relation to Islet 6, with a close up image of Islet 6 showing hauled out seal lions.

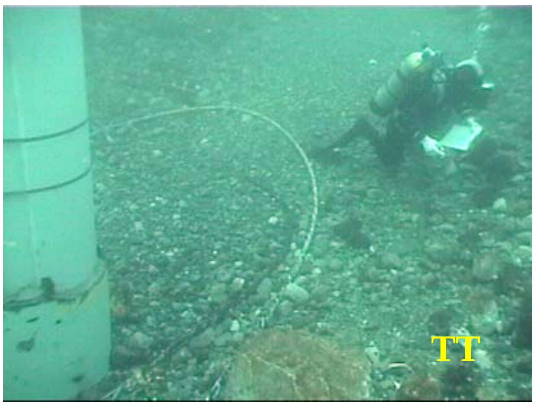
Harbour seals were scattered on rocks throughout the Reserve and a single California sea lion remained hauled out on North Race Rock throughout construction. A small number of pelagic cormorants were resting in sub-area G on Great Race Rock, and resting gulls were the only other birds observed in the Reserve. Overall results from these observations suggested that there was very little impact on the wildlife within the Reserve, as there was no detectable marine mammal or bird disturbance during any phase of the construction project.

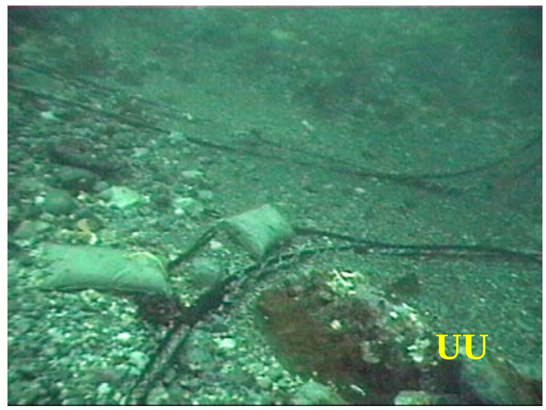
4.0 POST CONSTRUCTION MONITORING

4.1 TURBINE SITE

On September 21, 2006, divers collected observations of the pile excavation site and clamshell dredge spoil area in the immediate vicinity of the pile. These observations were collected 45 days after the pile was installed and 28 days following the submarine cable installation. Observations of some of the biophysical features surrounding the pile include:

- An excavation area around the installed pile between approximately 12-16m in diameter (Figure 9) with clean pebble and cobble (Photo TT, looking west; Photo UU, looking at the power cables running southeast).

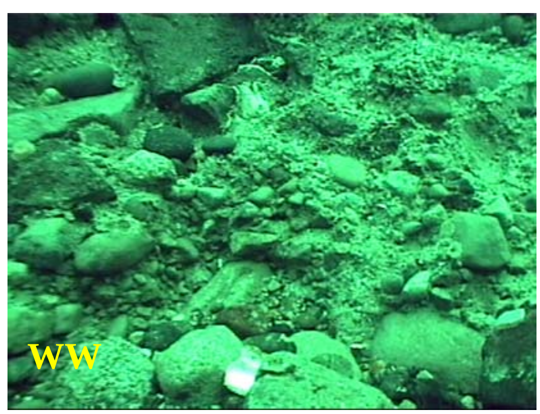




- A transition area between the pile location and non-impacted seabed where material (pebble and cobble) from the dredge spoil is dispersed over the natural seabed (Photo VV). This area extends approximately 20m east along the cable route and west along the direction of tidal flow.

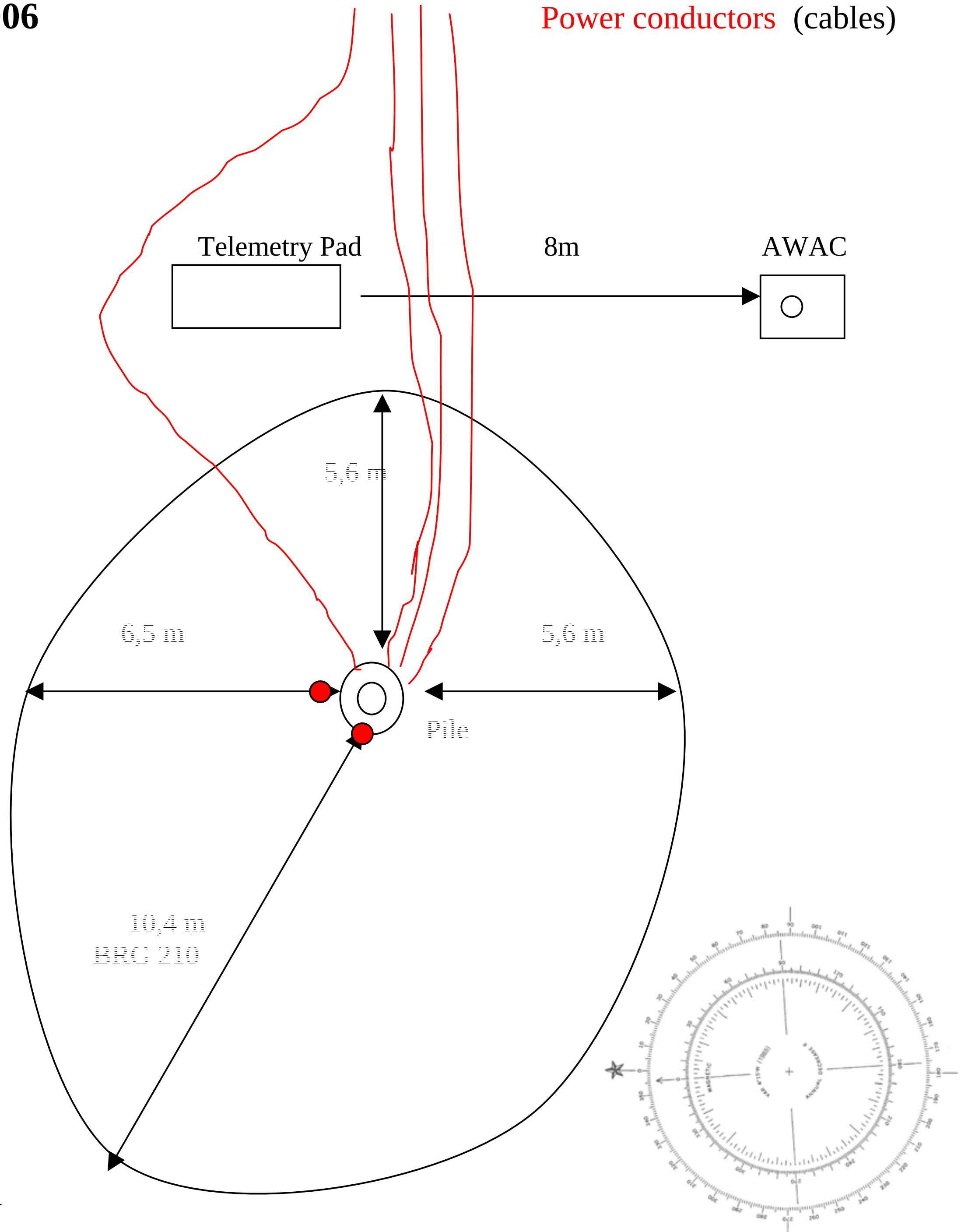
- Settlement of *Epiactis* (brooding anemone) and *Metridium* on exposed bedrock and cobble.

- Some areas of exposed clay embedded with cobble and pebble on the north slope of the excavation area (Photo WW, close view).



TURBINE SITE LAYOUT

04/11/2006



TOP VIEW

Date: 13/08/2006 Time: 1435 hrs	Easting: 460405 Northing: 5349979	Tidal Height at Time of Mapping: 1,6 m

Figure 9. Turbine site layout (top view) with approximate location of boulders (in red; see Section 5.0)(provided by Pearson College).

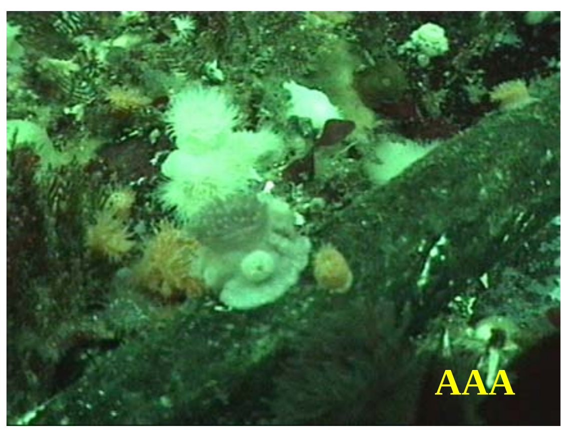
4.2 Cable Route

Divers collected video imagery along the cable route on September 20, 2006. Observations included:

- Two cables crossed one another at various points along the cable route (Photos XX);

- At various locations along the cable route, the cables were separated from each other at distances greater than could be observed due to the visibility conditions (approximately 10m);
- Near the jetty, the fibre optic line attached to a cable "billowed" at several locations (Photo YY showing separation; Photo ZZ showing bundled power and fibre optic cables);

- *Epiactis* (brooding anemone) were present on the cable in a number of locations (Photo AAA).



- Several of the cables observed remained off the bottom for a large percent of the length of the cable (30 – 50%) (Photo BBB, CCC).

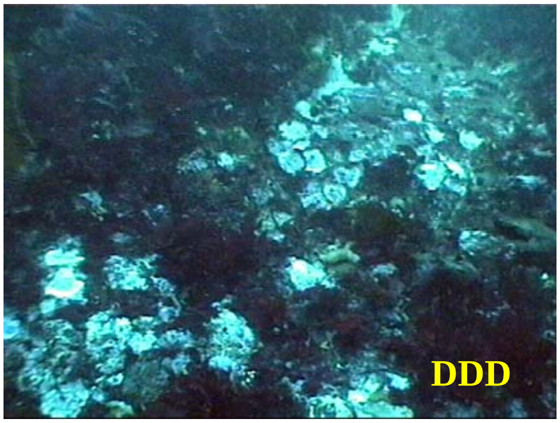

BBB

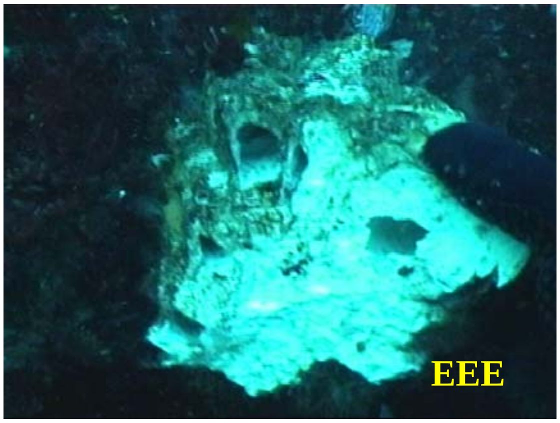

CCC

4.3 ANCHOR BLOCK

Due to concerns that one of the anchor blocks used to hold the drilling barge in place moved along the seabed during construction activity in July, dive observations were collected in the vicinity of anchor block #3 (see Figure 4) on September 20, 2006. Observations included:

- Some evidence that the anchor block dislodged giant acorn barnacles (*Balanus nubilus*) (Photo DDD, white barnacle scar on rock, Photo EEE, underside of *B. nubilus* cluster removed from rock).


DDD

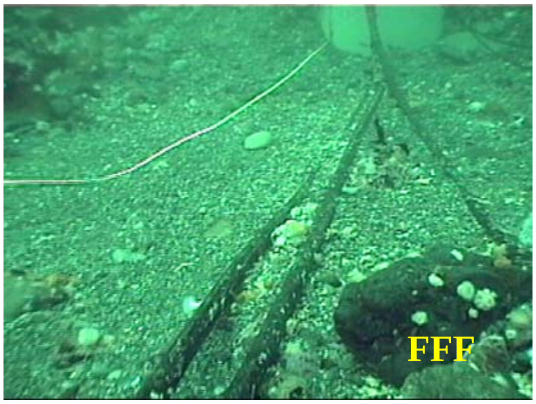

EEE

- The impact was in a very localized area and was restricted to *B. nubilus*. There was no visible impact to vegetation or other sensitive invertebrate species (e.g., sponges, hydrocorals).

5.0 FUTURE MONITORING RECOMMENDATIONS

The intent is to leave the tidal turbine generator (as a prototype) in place for a five-year period. During that time, it is recommended that Pearson College students conduct monitoring of the impacted area of seabed in the vicinity of the turbine site. Although impacts to the seabed were anticipated, it is important to document the recovery of the seabed through systematic observations over time to help understand the recolonization process in an area of high current and resulting high biological diversity. Several monitoring opportunities exist and include:

- Use of the submarine cable to document the impacted area over time. The cable could be permanently marked at known distances (e.g. 5m intervals) originating at the base of the pile (Photo FFF) and observations within the excavation crater (distance, substrate, sessile invertebrates) and the transition zone (mixture of dredge spoil and natural seabed) could be documented quarterly (on an annual basis) to capture seasonal effects.


FFF

- Use of the protruding rock immediately north (Photo GGG) or west (Photo HHH, with sponge) of the turbine (see Figure 9) to document sediment movement and composition. The base of the pile could be incrementally marked at the base and used to measure material deposition or erosion. Invertebrate colonization on the rock could also be documented (counts or percent cover by species) during the same quarterly monitoring period.


GGG


HHH

- Choice of one site within the dredge spoil area south of the pile that could be easily marked, to document recovery of the seabed (substrate and biota) over time (quarterly on an annual basis). The focus would be to document the movement of dredge material that currently smothers a portion of the seabed (Phoh III, base of *Metridium* buried) and the re-colonization rate of sessile and mobile invertebrate species.

6.0 REFERENCES

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Demarchi, M.W. and M.D. Bentley. 2004. Effects of natural and human-caused disturbances on marine birds and pinnipeds at Race Rocks, British Columbia. LGL Report EA 1569. Prepared for Department of National Defence, Canadian Forces Base Esquimalt and Public Works and Government Services Canada. 103 p.

Niet, T. and G. McLean. 2001. Race Rocks Sustainable Energy System Development. In proceedings from the 11th Canadian Hydrogen Conference, pp535 – 544, Victoria B.C. June 17-21, 2001.

Appendix 1

Detailed Transect Information from T1 – T3 on Great Race Rocks

Biophysical transect information for Race Rocks collected April 27, 2005.

Barge landing site

Vertical elevation/depth given in metres relative to chart datum. ***dGPS start:*** **48^0 17.920 123^0 31.846**

Invertebrates: A = Abundant, C = Common, P = Present. ***dGPS end:*** **48^0 17.937 123^0 31.840**

Vegetation: % cover estimated for dominant vegetation.

Transect ID	Elevation (m)	Slope Distance (m)	Substrate (in order of composition)	Vegetation Latin Name	Vegetation Common Name	% cover	Invertebrates Latin Name	Invertebrates Common Name	Abund.
1	3.7 to 3.6	0 to 7.9	boulder bedrock		grass	10-20	none		
	3.6 to 2.8	7.9 to 15.6	cobble pebble	none			none		
	2.8 to 2.5	15.6 to 25.5	bedrock	*Porphyra perforata*	Purple laver Fine filamentous green algae	10-20 30	none		
	2.5 to 2.5	25.5 to 26.5	bedrock	*Porphyra perforata*	Purple laver	10-20	*Semibalanus cariosus* *Pollicipes polymerus*	Thatched barnacle Goose neck barnacle	C clumps
	2.5 to 1.2	26.5 to 32.2	bedrock	*Fucus* sp. *Endocladia muricata* *Halosaccion glandiforme*	Rockweed Sea moss Sea sacs	20 30 10	*Semibalanus cariosus*	Thatched barnacle	C
	1.2 to 0.4	32.2 to 37.1	bedrock	*Phyllospadix* sp. *Hedophyllum sessile* *Alaria sp.* *Coralline red algae* *Palmaria sp.* *Prionitis lanceolata*	Surf grass Sea cabbage Ribbon kelp Encrusting/erect Red ribbon Bleachweed Fine filamentous green algae	<10 20 20 20 10 10 10	*Semibalanus cariosus* *Pollicipes polymerus* *Mytilus californianus* *Tectura scutum* *Cucumaria miniata* *Katharina tunicata*	Thatched barnacle Goose neck barnacle California mussel Plate limpet Orange sea cucumber Black chiton	A clumps C C P P

Archipelago Marine Research Ltd.

Biophysical transect information for Race Rocks collected April 27, 2005.

Directional Drill Path

Vertical elevation/depth given in metres relative to chart datur ***dGPS start:*** **48^0 17.928** **123^0 31.859**

Invertebrates: A = Abundant, C = Common, P = Present. ***dGPS end:*** **48^0 17.937** **123^0 31.867**

Vegetation: % cover estimated for dominant vegetation.

Transect ID	Elevation (m)	Slope Distance	Substrate (in order of composition)	Vegetation Latin Name	Vegetation Common Name	Vegetation % cover	Invertebrates Latin Name	Invertebrates Common Name	Abund.
2	3.8 to 4.2	0 to 5.2	bedrock	none			none		
	4.2 to 2.8	5.2 to 7	bedrock	none			none		
	2.8 to 2.8	7 to 13.5	bedrock	*Verrucaria*	Black lichen		*Semibalanus cariosus*	Thatched barnacle	C
				Porphyra perforata	Purple laver	10-20			
	2.8 to 1.8	13.5 to 16.3	bedrock	*Fucus* sp.	Rockweed	20	*Semibalanus cariosus*	Thatched barnacle	A
				Endocladia muricata	Sea moss	10	*Tectura scutum*	Plate limpet	C
				Halosaccion glandiforme	Sea sacs	10			
				Ulva sp.	Sea lettuce	10			
					Foliose red algae	10			
	1.8 to 1.4	16.3 to 18.7	bedrock	*Halosaccion glandiforme*	Sea sacs	20-30	*Semibalanus cariosus*	Thatched barnacle	A
				Ulva sp.	Sea lettuce	20			
	1.4 to 0.4	18.7 to 22.35	bedrock	*Phyllospadix* sp.	Surf grass	<10	*Semibalanus cariosus*	Thatched barnacle	A
				Hedophyllum sessile	Sea cabbage	20	*Pollicipes polymerus*	Goose neck barnacle	clumps
				Alaria sp.	Ribbon kelp	20	*Mytilus californianus*	California mussel	C
				Coralline red algae	Encrusting/erect	20	*Tectura scutum*	Plate limpet	C
				Odonthalia sp.	Sea brush	10	*Katharina tunicata*	Black chiton	C

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Biophysical transect information for Race Rocks collected May 12, 2005.

Mid Bay (Jetty)

Vertical elevation/depth given in metres relative to chart datum. ***dGPS start:*** **48⁰ 17.915 123⁰ 31.900**

Invertebrates: A = Abundant, C = Common, P = Present. ***dGPS end:*** **48⁰ 17.931 123⁰ 31.893**

Vegetation: % cover estimated for dominant vegetation.

Transect ID	Elevation (m)	Slope Distance (m)	Substrate (in order of composition)	Vegetation: Latin Name	Common Name	% cover	Invertebrates: Latin Name	Common Name	Abund.
3	3.5 to 2.3	0 to 7	rubble (boulder/cobble/pebble) drift logs	none			*Hemigrapsus* (under rubble)	Shore crab	C
	2.3 to 1.9	7 to 13.2	boulder cobble pebble bedrock	*Porphyra perforata*	Purple laver	<10	*Littorina*	Periwinkle	C
				Verrucaria	Black lichen		*Semibalanus cariosus*	Thatched barnacle	C
	1.9 to 1.2	13.2 to 21.8	larger boulder on cobble/ pebble bedrock	*Endocladia muricata*	Sea moss	<10	*Semibalanus cariosus*	Thatched barnacle	C
				Mastocarpus pappilatus	Turkish washcloth	<10	*Balanus glandula*	Acorn barnacle	C
							Tectura scutum	Plate limpet	P
							Lottia sp.	Limpet	P
	1.2 to 1	21.8 to 22.7	bedrock boulder	*Fucus* sp.	Rockweed	10	*Balanus glandula*	Acorn barnacle	C
							Semibalanus cariosus	Thatched barnacle	C
	1 to 0.7	22.7 to 25.6	boulder on pebble/shell	*Hedophyllum sessile*	Sea cabbage	10	*Semibalanus cariosus*	Thatched barnacle	A
				Fucus sp.	Rockweed	10	*Tectura scutum*	Plate limpet	P
				Ulva sp.	Sea lettuce	10	*Littorina*	Periwinkle	C
				Halosaccion glandiforme	Sea sacs	<5	*Mytilus californianus*	California mussel	P
				Mastocarpus pappilatus	Turkish washcloth	10	*Nucella*	Whelk	P
				Porphyra perforata	Purple laver	<5	*Anthopleura*	Green anemone	P
				Coralline red algae	Encrusting/erect	20	*Katharina tunicata*	Black chiton	C
				Odonthalia sp.	Sea brush	10			
	0.67 to 0.4	25.6 to 28.3	bedrock	*Alaria sp.*	Ribbon kelp	60	*Semibalanus cariosus*	Thatched barnacle	A
				Hedophyllum sessile	Sea cabbage	20	*Mytilus californianus*	California mussel	P
				Ulva sp.	Sea lettuce	10	*Tectura scutum*	Plate limpet	P
				Acrosiphonia	Sea Moss	10	*Katharina tunicata*	Black chiton	P
				Odonthalia sp.	Sea brush	10		orange demosponge	P

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Appendix 2

Species List – Dive and Towed Video Observations Pre Construction

Species List (invertebrates, fish and marine algae) from subtidal observations (0.0 - 19.8m depth CD) along the cable route and at the turbine site (Oct. - Nov. 2005)

Invertebrates

Scientific Name	**Common Name**
Sea Stars	
Crossaster papposus	Rose star
Evasterias troschelli	Mottled star
Stylasterias forreri	Long-rayed star
Henricia sp.	
Pycnopodia helianthoides	Sunflower star
Solaster stimpsoni	Striped sun star
Orthasterias koehleri	Rainbow star
Dermasterias imbricata	Leather star
Sea Urchins	
Strongylocentrotus franciscanus	Red sea urchin
Strongylocentrotus droebachiensis	Green sea urchin
Sea Cucumbers	
Psolus chitonoides	Creeping pedal sea cucumber
Cucumaria miniata	Orange sea cucumber
Brittle Stars	
Ophiura sp. (likely *lutkeni*, arms only)	Brittle star
Anemones, Cup corals, Zoanthids	
Metridium giganteum	Giant plumose anemone
Metridium senile	Short plumose anemone
Epiactus sp.	Brooding anemone
Urticina crassicornis	Painted anemone
Urticina sp.	Anemone
Cribrinopsis fernaldi	Crimson anemone
Unidentified anemone	
Balanophyllia elegans	Orange cup coral
Sponges	
Encrusting/erect demosponges including:	
Isodictya sp.	Erect sponge
Myxilla lacunosa	Sulphur sponge
Unknown encrusting red sponge	Red sponge
Hydroids including:	
Plumularia spp.	Glassy plume hydroids
Abietinaria spp.	hydroid
Aglaophenia spp.	hydroid
Ectopleura (*Tubularia*)	hydroid
Thuiaria spp.	Sea fir hydroid

Invertebrates

Scientific Name	**Common Name**
Hydrocorals (erect/encrusting) including:	
Stylantheca (Allopora) spp.	hydrocoral
Stylaster spp.	hydrocoral
Ascidians	
Cystodytes lobatus	Lobed compound tunicate
Metandrocarpa taylori	Orange social ascidian
Unidentified compound and solitary ascidians	Unidentified compound and solitary ascidians
Bryozoans including:	
Heteropora sp.	Staghorn bryozoan
Membranipora sp.	Encrusting bryozoan (on *Desmarestia*)
Snail, Limpet, Nudibranch	
Acmaea mutra	Whitecap limpet
Diodora aspera	Keyhole limpet
Fusitriton oregonensis	Oregon Triton
Calliostoma sp. (likely *ligatum)*	Topsnail
Unidentified snails	Unidentified snails
Chlamys sp.	Swimming scallop
Crassadoma gigantea	Rock scallop
Tonicela lineata	Lined chiton
Cryptochiton stelleri	Gumboot chiton
Unidentified dorid nudibranch	Nudibranch
Tube Dwelling Worm	
Myxicolla infundibulum	Slime tube worm
Unidentified Serpulidae	Calcareous tube worms
Dodecaceria sp.	Clustering tube worms
Unidentified Saballidae	Parchment tube Worms
Crab, Shrimp, Barnacle	
Pandalus danae	Coonstripe shrimp
Pagurus spp.	Hermit crab
Balanus nubilus	Giant acorn barnacle

Fish

Scientific Name	**Common Name**
Sebastes maliger	Quillback rockfish
Sebases caurinus	Copper rockfish
Ophiodon elongatus	Lingcod
Hexagrammos decagrammus (male and female)	Kelp greenling
Scorpaenichthys marmoratus	Cabezon
Family Cottidae	Unidentified Sculpin

Vegetation

Scientific Name	**Common Name**
Brown Algae	
*Pterygophora californica**	Woody-stemmed kelp
*Laminaria setchellii**	Sugar kelp
Laminaria saccharina	Stiff-stiped kelp
Laminaria bongardiana (groenlandica)	Split kelp
Laminaria sp. (stipes)	
Nereocystis leutkeana	Bull kelp
Alaria sp. (*marginata* morph)	Winged kelp
Pleurophycus gardneri	Sea spatula
Cymathere triplicata	Three-ribbed kelp
Costaria costata	Seersucker
Agarum fimbriatum	Fringed sieve kelp
Desmarestia sp. (foliose + filamentous)	Acid kelp
Cystosiera geminata (stipes only)	Bladder leaf
Filamentous/foliose red algae including:	
Opunteilla californica	Red opuntia
Odonthalia sp.	Rockweed brush
Polysiphonia sp.	Filamentous red algae
Cryptopleura ruprechtiana	Hidden rib
Mazzaella splendens	Splendid iridescent seaweed
Coralline red algae (erect and encrusting):	
Lithothamnion sp.	Rock crust
Bossiella spp./*Calliarthron* spp.	Erect coralline red algae
Green Algae	
Ulva spp.	Sea lettuce

*Both these species were documented at 19m depth, growing beside one another on rock near the turbine site. These species can be found in association with one another at depths to 20m at high energy sites (wave or current) (Emmett *et al.* 1995).

Appendix 3

Estimate of Dispersion of Drill Effluent

Estimate of dispersion of drill waste material released at the water surface at Race Rocks

To estimate the dispersion of material released at the water surface and its impact at the seabed we calculated the sinking rates of particles of various sizes and estimated their distance of travel given the current speeds at Race Rocks. The range of particle travel distances (in the predominant directions of ebb and flood) from their release point are given below.

Particle size	Distance from release point
1mm dia.	= +/-130m
0.5mm dia	= +/- 530m
0.3mm dia	= +/- 1,475m
0.2mm dia	= +/- 3,320m
0.1mm dia	= +/-13,275m

Assumptions:
Water depth = 20m
Range of current speed = 0 to 1.5 m/s in both ebb and flood directions
Volume of material released = 0.5m^3 (provided by drill operator)

If we assume all 0.5 m^3 is deposited within a 3km x 10m area, the height of the sediment deposition layer would be 0.017mm, or less than 1 average particle size high.

Given the seabed sediment grain size present at Race Rocks is very coarse (primarily cobble and boulder with sparse amounts of pebble and coarse sand), the currents would likely continue to disperse any fine particles from the drill effluent once material reached the seabed; therefore it is highly unlikely any sediment accumulation within the Race Rocks area will result from the release of drilling effluent at the water surface.

Appendix 4

Marine Mammal and Marine Bird Observations

Table 1. Summary of marine mammal and bird species observed in Race Rocks Ecological Reserve in the morning before the start of drill rig anchoring, July 16, 2006, 08:00 hours, high tide.

Islet Number	Harbor Seal	Steller Sea Lion	California Sea Lion	Elephant Seal	Gull	Bald Eagle	Pigeon Guillemot	Pelagic Cormorant	Double Crested Cormorant	Oyster Catcher
1	0	0	0	0	1	0	0	0	0	0
2	17	1	0	0	0	2	0	0	0	0
3	15	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	3	0	0	0	80	0	0	0	0	0
6	0	0	0	0	4	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0
8	9	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0
10	14	0	0	0	0	0	0	0	0	0
11	0	2	0	0	0	0	0	0	0	0
Jetty	0	0	0	0	0	0	0	0	0	0
A	3	0	0	0	21	0	18	0	0	0
B	0	0	0	0	100	0	0	0	0	0
C	0	0	0	0	0	0	0	0	0	0
D	0	0	0	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0	0	0	0
F	0	0	0	0	200	0	4	0	0	0
G	0	0	0	5	45	0	31	0	0	0
H	0	0	0	0	0	0	0	0	0	0
I	0	0	0	0	0	0	0	0	0	0
Total	**61**	**3**	**0**	**5**	**451**	**2**	**53**	**0**	**0**	**0**

Table 2. Summary of marine mammal and bird species observed in Race Rocks Ecological Reserve mid-day during drill rig anchoring, July 16, 2006, 12:00 hours, low tide.

Islet Number	Harbor Seal	Steller Sea Lion	California Sea Lion	Elephant Seal	Gull	Bald Eagle	Pigeon Guillemot	Pelagic Cormorant	Double Crested Cormorant	Oyster Catcher
1	0	0	0	0	1	0	0	0	0	0
2	8	0	0	0	80	0	0	0	0	0
3	1	0	0	0	60	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	11	0	0	0	7	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0
7	1	0	0	0	50	0	0	0	0	0
8	15	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0
10	20	0	0	0	80	0	0	0	0	1
11	25	0	0	0	0	0	0	0	0	0
Jetty	0	0	0	0	0	0	0	0	0	0
A	0	0	0	0	0	0	0	0	0	0
B	0	0	0	0	30	0	0	0	0	0
C	0	0	0	0	80	0	0	0	0	0
D	14	0	0	0	91	0	0	0	0	0
E	0	0	0	0	0	0	0	0	0	0
F	0	0	0	0	0	0	0	0	0	0
G	0	0	0	0	0	0	0	0	0	0
H	0	0	0	0	1	0	0	0	0	0
I	106	0	0	0	0	0	0	0	0	0
Total	**201**	**0**	**0**	**0**	**480**	**0**	**0**	**0**	**0**	**1**

Table 3. Summary of marine mammal and bird species observed in Race Rocks Reserve in the afternoon near the end of drill rig anchoring, July 16, 2006, 16:00 hours, high tide.

Islet Number	Harbor Seal	Steller Sea Lion	California Sea Lion	Elephant Seal	Gull	Bald Eagle	Pigeon Guillemot	Pelagic Cormorant	Double Crested Cormorant	Oyster Catcher
1	0	0	0	0	0	0	0	0	0	0
2	1	0	0	0	1	0	0	0	0	0
3	24	0	0	0	100	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	1	0	0	0	40	0	0	0	0	0
6	7	0	0	0	15	0	0	0	0	0
7	2	0	0	0	25	0	0	0	0	0
8	12	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0
10	32	0	0	0	100	0	0	0	0	0
11	13	0	0	0	0	0	0	0	0	0
Jetty	0	0	0	4	0	0	0	0	0	0
A	0	0	0	0	0	0	0	0	0	0
B	0	0	0	0	12	0	0	0	0	0
C	0	0	0	0	60	0	0	0	0	0
D	36	0	0	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0	0	0	0
F	0	0	0	0	60	0	0	0	0	0
G	0	0	0	0	60	0	0	2	0	0
H	54	0	0	0	1	0	0	0	0	0
I	0	0	0	0	0	0	0	0	0	0
Total	**182**	**0**	**0**	**4**	**474**	**0**	**0**	**2**	**0**	**0**

Table 4. Summary of marine mammal and bird species observed in Race Rocks Ecological Reserve in the morning before the start of drilling activity, July 21, 2006, 08:00 hours, low tide.

Islet Number	Harbor Seal	Steller Sea Lion	California Sea Lion	Elephant Seal	Gull	Bald Eagle	Pigeon Guillemot	Pelagic Cormorant	Double Crested Cormorant	Oyster Catcher
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	23	0	0	0	0	0	0	0	0	0
4	6	0	0	0	0	0	0	0	0	0
5	7	0	0	0	0	0	0	0	0	0
6	12	0	0	0	0	0	0	0	0	0
7	25	0	0	0	0	0	0	0	0	0
8	10	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0
10	46	0	0	0	0	0	0	0	0	1
11	102	0	0	0	0	0	0	0	0	0
Jetty	0	0	0	2	0	0	27	0	0	2
A	0	0	0	0	18	0	8	0	0	0
B	0	0	0	0	0	0	0	0	0	0
C	0	0	0	0	0	0	0	0	0	0
D	2	0	0	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0	0	0	0
F	10	0	0	0	24	0	0	0	0	0
G	0	0	0	0	40	0	22	0	5	2
H	19	0	0	0	145	0	0	0	0	0
I	78	0	0	0	0	0	0	0	0	0
Total	**340**	**0**	**0**	**2**	**227**	**0**	**57**	**0**	**5**	**5**

Table 5. Summary of marine mammal and bird species observed in Race Rocks Ecological Reserve mid-day during drilling activity, July 21, 2006, 12:00 hours, mid-tide rising.

Islet Number	Harbor Seal	Steller Sea Lion	California Sea Lion	Elephant Seal	Gull	Bald Eagle	Pigeon Guillemot	Pelagic Cormorant	Double Crested Cormorant	Oyster Catcher
1	1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	10	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	39	0	0	0	0	0
6	13	0	0	0	2	0	0	0	0	0
7	0	0	0	0	30	0	0	0	0	0
8	4	0	0	0	50	0	0	0	0	0
9	4	0	0	0	4	0	0	0	0	0
10	30	0	0	0	0	0	0	0	0	1
11	11	0	0	0	0	0	0	0	0	0
Jetty	0	0	0	2	17	0	18	0	0	0
A	0	0	0	0	0	0	0	0	0	0
B	0	0	0	0	0	0	0	0	0	0
C	0	0	0	0	0	0	0	0	0	0
D	3	0	0	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0	0	0	0
F	0	0	0	0	43	0	0	0	0	1
G	0	0	0	0	40	0	11	2	7	0
H	17	0	0	0	0	0	0	0	0	0
I	0	0	0	0	0	0	0	0	0	0
Total	**93**	**0**	**0**	**2**	**225**	**0**	**29**	**2**	**7**	**2**

Table 6. Summary of marine mammal and bird species observed in Race Rocks Ecological Reserve in the morning before the start of cable laying, August 15, 2006, 09:00 hours, high tide.

Islet Number	Harbor Seal	Steller Sea Lion	California Sea Lion	Elephant Seal	Gull	Bald Eagle	Pigeon Guillemot	Pelagic Cormorant	Double Crested Cormorant	Oyster Catcher
1	0	4	1	0	0	0	0	0	0	0
2	0	0	0	0	180	0	0	0	0	0
3	20	4	0	4	150	0	0	0	0	0
4	12	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0
6	0	6	21	0	0	0	0	0	0	0
7	1	0	0	0	0	0	0	0	0	0
8	4	0	1	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0
10	16	1	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0
Jetty	0	1	6	0	50	0	18	0	0	0
A	24	0	0	0	0	0	0	0	0	0
B	21	0	0	0	0	0	0	0	0	0
C	21	0	0	0	0	0	0	0	0	0
D	20	0	0	0	0	0	0	0	0	0
E	8	0	0	0	0	0	0	0	0	0
F	1	0	0	0	100	0	0	0	0	0
G	0	0	0	0	0	0	5	4	0	0
H	0	0	0	0	0	0	0	0	0	0
I	0	0	0	0	0	0	0	0	0	0
Total	**148**	**16**	**29**	**4**	**480**	**0**	**23**	**4**	**0**	**0**

Table 7. Summary of oceanographic conditions during observation days at Race Rocks Ecological Reserve.

Date	Time	Tide	Wind Speed (kts)	Wind Direction	Sea State	Swell Height (feet)	Visibility (miles)
16-Jul	8:00	High	5	W	Rippled	0	7
16-Jul	12:00	Low	10	W	Rippled	0	7
16-Jul	16:00	High	20	W	2' chop	0	7
21-Jul	8:00	Low	2	ESE	Calm	0	10
21-Jul	12:00	Mid-tide rising	2	ESE	Calm	0	7
15-Aug	9:00	High	5	WSW	Rippled	2	7

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